



National Aeronautics and  
Space Administration

Washington, D.C.  
20546

Reply to Attn of

GP-4

TO: NST-44/Scientific and Technical Information Division  
Attn: Shirley Peigare

FROM: GP-4/Office of Assistant General Counsel  
for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP-4 and Code NST-44, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 4,377,371

Government or  
Contractor Employee: U.S. Government

NASA Case No. : LEW-13,269-1

NOTE - If this patent covers an invention made by a contractor employee under a NASA contract, the following is applicable:

YES ☐

NO ☒

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the specification, following the words "...with respect to an invention of...."



N83-20996

(NASA-Case-LEW-13269-1) LASER SURFACE  
FUSION OF PLASMA SPRAYED CERAMIC TURBINE  
SEALS Patent (NASA) 5 p CSCL 22B

Unclas  
00/18 11073

**United States Patent** [19]

Wisander et al.

[11] **4,377,371**[45] **Mar. 22, 1983****[54] LASER SURFACE FUSION OF PLASMA  
SPRAYED CERAMIC TURBINE SEALS****[75] Inventors:** Donald W. Wisander, Columbia  
Station; Robert C. Bill, Rocky River,  
both of Ohio**[73] Assignee:** The United States of America as  
represented by the Administrator of  
the National Aeronautics and Space  
Administration, Washington, D.C.**[21] Appl. No.:** 242,795**[22] Filed:** Mar. 11, 1981**[51] Int. Cl.<sup>3</sup>** ..... **F01D 11/08****[52] U.S. Cl.** ..... **415/174; 415/197****[58] Field of Search** ..... 415/9, 174, 197**[56] References Cited****U.S. PATENT DOCUMENTS**

2,930,521	3/1960	Koehring	415/174
3,545,944	12/1970	Emanuelson	415/179 UX
3,817,719	12/1974	Schilke	415/174 X
3,879,831	4/1975	Rigney et al.	415/174 X
3,975,165	8/1976	Elbert et al.	415/174 X
4,004,042	1/1977	Fairbairn	427/34
4,024,617	5/1977	McCormick	29/156.63
4,080,204	3/1978	Panzera	415/174 X
4,145,481	3/1979	Gupta et al.	428/678
4,247,249	1/1981	Siemens	415/174

4,280,975 7/1981 Ammann ..... 415/200 X

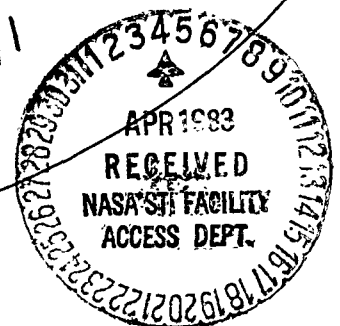
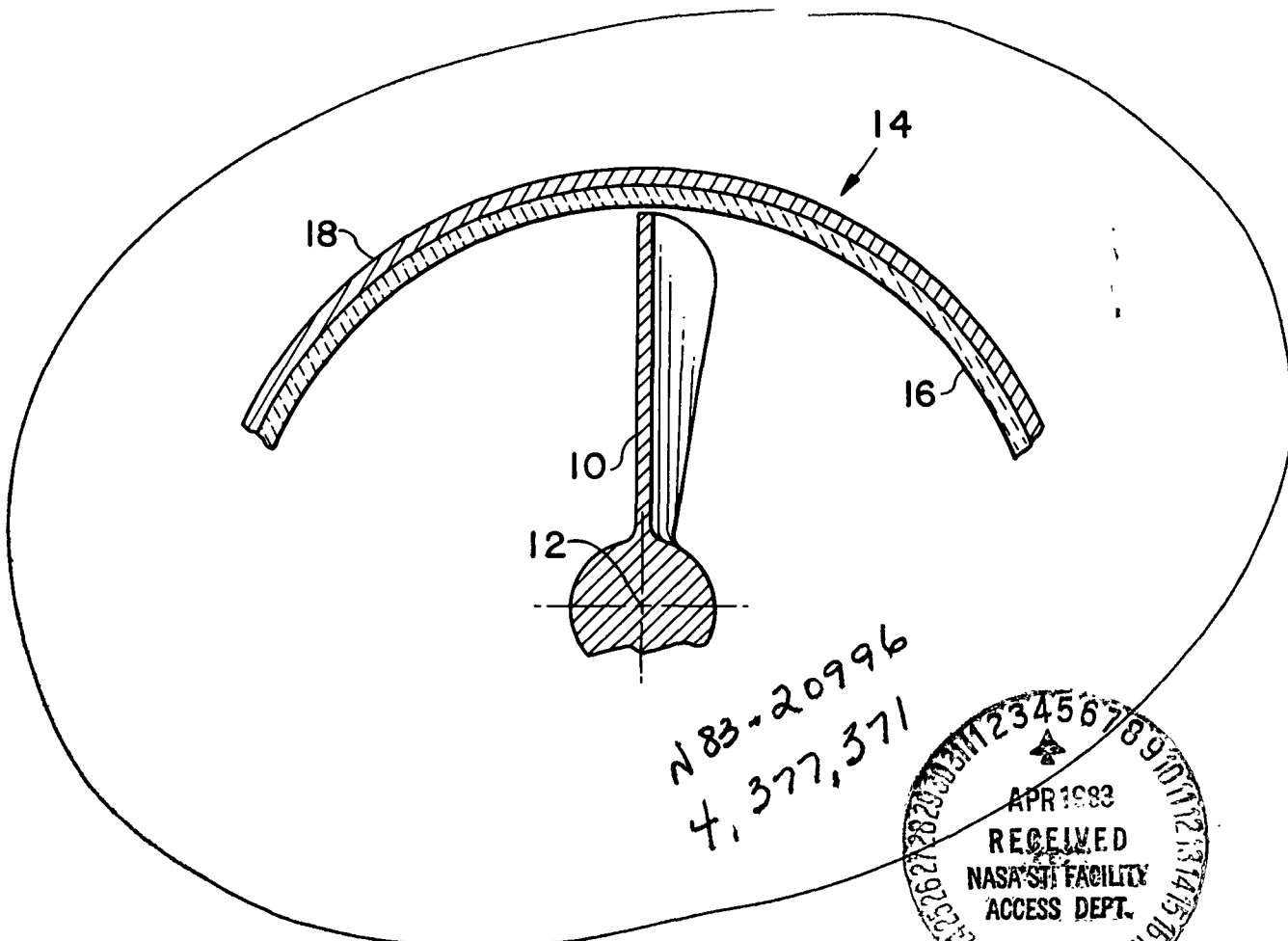
*Primary Examiner*—Philip R. Coe*Assistant Examiner*—Frankie L. Stinson*Attorney, Agent, or Firm*—Norman T. Musial; John R.  
Manning; Gene E. Shook**[57] ABSTRACT**

This invention is directed to improving the thermal shock resistance of a ceramic layer. The invention is particularly directed to an improved abradable lining (16) that is deposited on a shroud (14) forming a gas-path seal in turbomachinery.

Improved thermal shock resistance of a shroud is effected through the deliberate introduction of "benign" cracks. These are microcracks which will not propagate appreciably upon exposure to the thermal shock environment in which a turbine seal must function.

Laser surface fusion treatment is used to introduce these microcracks. The ceramic surface is laser scanned to form a continuous dense layer as shown in FIG. 2. As this layer cools and solidifies, shrinkage results in the formation of a very fine crack network.

The presence of this deliberately introduced fine crack network precludes the formation of a catastrophic crack during thermal shock exposure.

**8 Claims, 3 Drawing Figures**

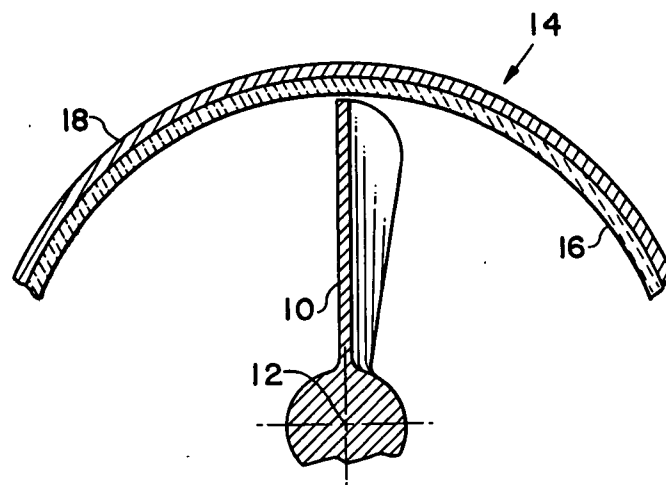


FIG. 1



FIG. 2

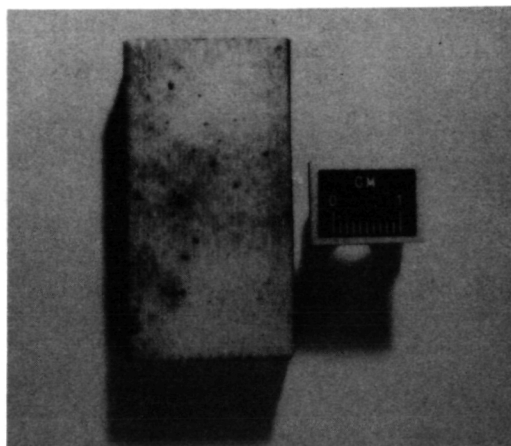


FIG. 3

# LASER SURFACE FUSION OF PLASMA SPRAYED CERAMIC TURBINE SEALS

## DESCRIPTION

### ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

### TECHNICAL FIELD

In the design of turbines or compressors of the like, especially those of high speed, it is understood that close tolerance between the tips of the blades and the surrounding shroud or housing which seals one side of the blades from the other is desirable. Such a seal reduces the return flow of fluid from the high pressure to the low pressure side. The closer the shroud surrounds the tips of the blades, the more efficient is the turbine or compressor. Aerodynamic losses are also reduced by closer fitting of the blade tips to the shroud.

This seal is achieved by designing the shroud to fit closely, say within 20 to 30 mils (i.e. about 5 to 7 mm.) about the tips of the blades at ambient temperature. Moreover the shroud about the blade is designed to be wearable or abradable relative to the blade tips. Then if there is a thermal transient or shock loading that causes a blade tip to strike the shroud, the blade material flakes off or abrades the shroud material, which may be a sprayed coating or sintered material of low density. Thus the shroud material is abradable (or wearable) with respect to the blade material.

Present day systems also employ either graded composition metal/ceramic layers applied by plasma spray deposition, or low density-low modulus sintered materials brazed to a support backing between a high temperature ceramic material adjacent to the hot turbine gas and a dense metal support backing. The ceramic layer is employed in the as-sprayed condition.

Such a ceramic layer is vulnerable to large scale spallation as cracks induced either by thermal stresses or present in the as-sprayed structure propagate the failure. There is no sufficiently effective crack arrest or local stress mitigation near existing crack tips in conventional as-sprayed structures.

### BACKGROUND ART

Fairbairn U.S. Pat. No. 4,004,042 is concerned with applying a wear and impact resistant coating by plasma-spraying tungsten carbide and nickel chrome boron powders onto a base metal. The coating is covered by a layer of nitrogen carried boric acid which forms a glossy protective film. The coating is then fused.

McCormick U.S. Pat. No. 4,024,617 is directed to applying a refractory coating to a ferrous metal substrate by providing a bonding element, such as nickel, at the interface and induction heating the coated substrate to the diffusion temperature.

A corrosion-resistant metal article is achieved by Gupta et al in U.S. Pat. No. 4,145,481 by applying ductile metal overlays. Porosity is limited by heating and applying isostatic pressure.

### DISCLOSURE OF INVENTION

This invention is concerned with improving the thermal shock resistance of a plasma-sprayed ceramic layer

such as that employed in an abradable lining forming a shroud that encircles the tips of high pressure turbine blades. Improved thermal shock resistance of the shroud is effected through the deliberate introduction of a network of "benign" cracks into the lining.

Benign cracks are defined as microcracks which will not propagate appreciably upon exposure to the thermal shock environment in which a turbine seal must function. Also, these benign cracks will inhibit the initiation of a new crack that may propagate to failure.

The benign crack network is generated by scanning a laser beam over the plasma-sprayed ceramic surface. The laser melts the ceramic material immediately beneath the beam, thereby producing a thin fused layer. Shrinkage accompanying cooling and solidification of the fused layer produces a network of microcracks that resists the formation and growth of a catastrophic crack during thermal shock exposure. An additional beneficial technical effect obtained from this process employed to generate the network of benign cracks is an improvement in the erosion resistance of the plasma-sprayed ceramic surface.

### BRIEF DESCRIPTION OF THE DRAWING

The objects, advantages, and novel features of the invention will be more fully apparent from the following detailed description when read in connection with the accompanying drawings in which

FIG. 1 is a schematic view in transverse cross-section of an arrangement for a turbine or a compressor shroud having an abradable lining treated in accordance with the invention.

FIG. 2 is a photomicrograph having a 250 magnification of a ceramic shroud that has been glazed by a laser beam in accordance with the present invention, and

FIG. 3 is a photograph of a plasma-sprayed ceramic layer after thermal shock testing.

### BEST MODE FOR CARRYING OUT THE INVENTION

Referring now to the drawing a rotor blade 10 of a turbine rotates about an axis 12 in a counter-clockwise direction as shown in the drawing. The fluid in which it operates flows in a direction into the paper. A shroud 14 surround the blade 10 and is substantially concentric with the axis 12.

The shroud 14 includes a layer 16 of a material that is abradable relative to the material in the blade 10. A sprayed ceramic coating 16 on a metal substrate 18 has been found to be suitable for this purpose.

According to the present invention a laser surface fusion treatment is relied on to introduce a fine microcrack network in the plasma-sprayed ceramic surface. More particularly, a laser beam is scanned over the ceramic surface producing a thin, uniform, fused layer on top of the plasma-sprayed ceramic surface.

During the laser fusion process, a thin layer about 0.005 inch thick is melted at the surface. This forms a continuous dense layer on top of the plasma-sprayed ceramic substrate, as shown in FIG. 2.

As this layer cools and solidifies, shrinkage results in the formation of a very fine crack network having a cell size of about 0.040 inch. This network has benign cracks extending a few mils into the ceramic structure. Also, some secondary microcrack damage may be done below this surface.